

Do You Know the Difference Between Process Life Cycle and Life Cycle Process?

May 18, 2012

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Software Engineering Subdivision

Prepared for:

Space and Missile Systems Center
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245-2808

Authorized by: Senior Vice President, Engineering and Technology Group

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Do You Know the Difference Between Process Life Cycle and Life Cycle Process?

Dr. Peter Hantos
The Aerospace Corporation

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Outline

- Objective
- Introduction
- Process Life Cycle Modeling
- System and Software Life Cycle Processes
- Conclusion
- Acronyms
- References



Objective

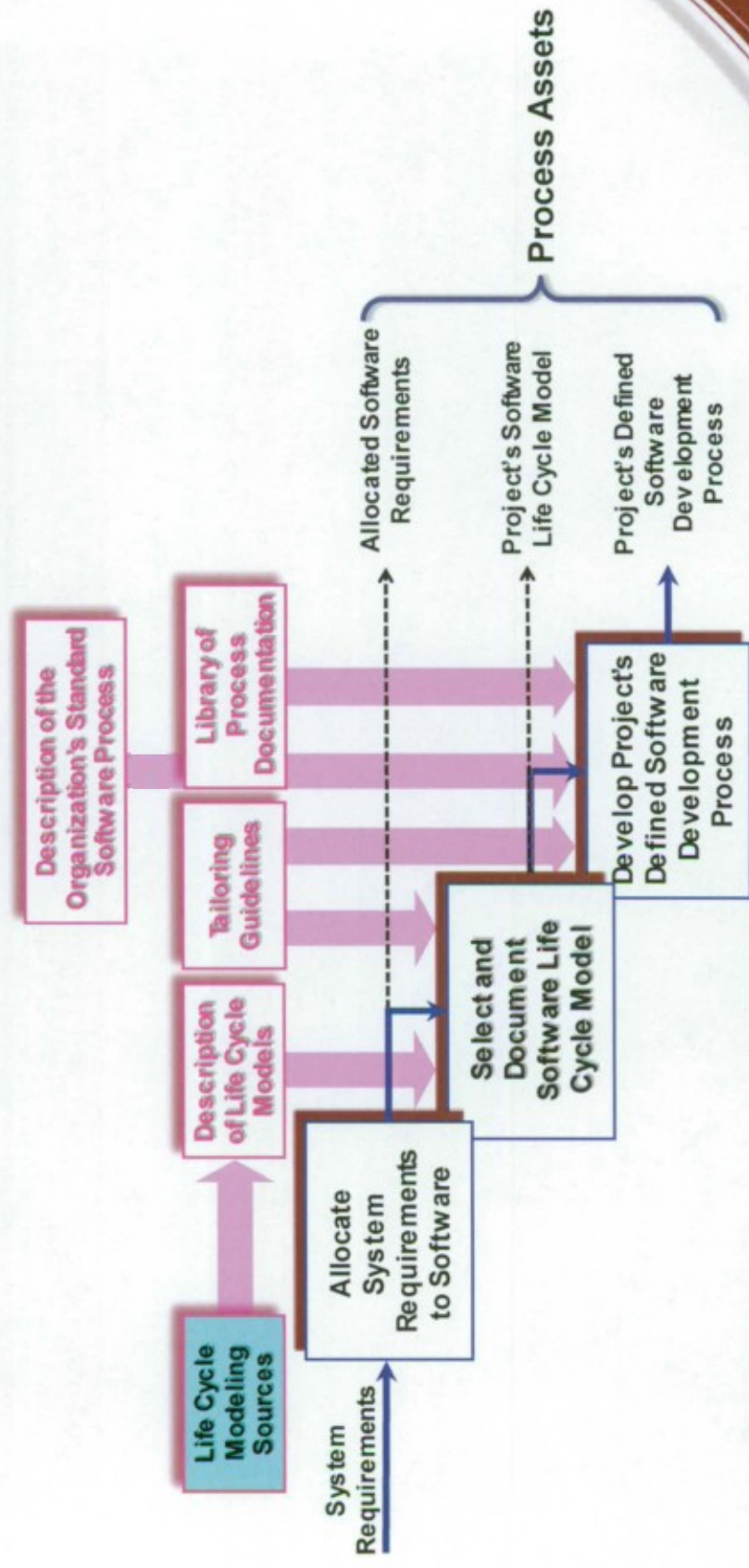
- The presentation's objective is to help with the consistent use of life cycle models and life cycle process standards
 - *Based on the presentation's title some might think that the issue is a simple grammatical confusion; however, this is not the case*
- Most project management frameworks emphasize the importance of the selection and documentation of an appropriate **life cycle model** for the project
- To increase predictability of the projects, there is a renewed interest in using **life cycle process standards** in acquisition
- Unfortunately, the two guidances are not sufficiently harmonized and key implementation details are missing or confusing
 - *As a result, blind reliance on life cycle process standards gives a false sense of security for the project manager*
 - *Wrong implementation can cause more harm than the perceived risk mitigation benefits*



Introduction

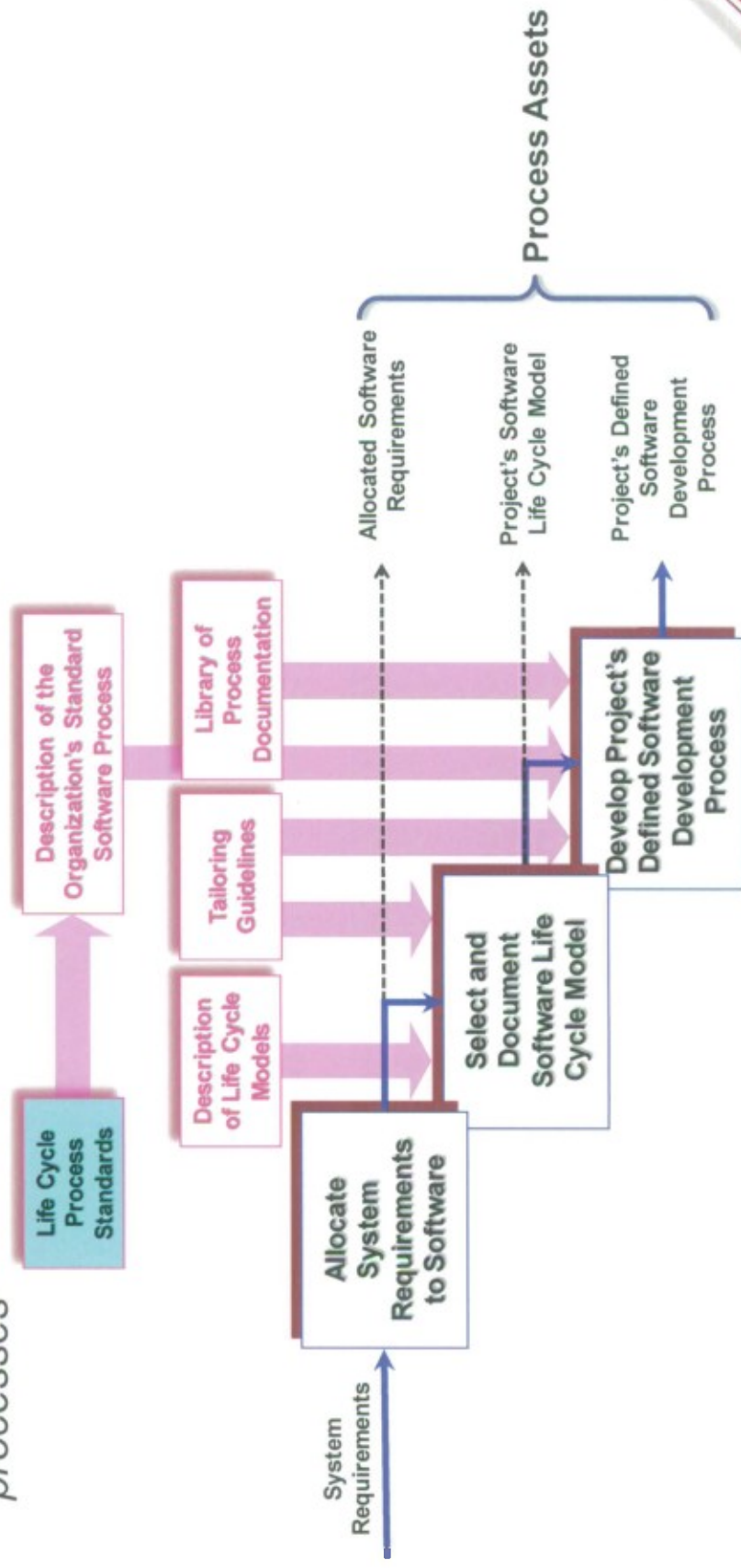
The Process Life Cycle Modeling Angle

- Process life cycle (model) == A view of the (development) process
 - Example: the chart demonstrates how the CMMI® [SEI 2010] describes the development of a project's software process using life cycle models



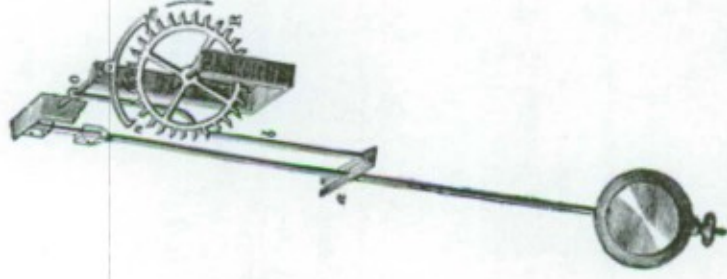
The Life Cycle Process Angle in Industry

- Life cycle process == Process component of the (development) process
 - *Life cycle process standards can be used to develop standard organizational processes*



Note that the CMMI only specifies the “what” and not the “how”

The Life Cycle Process Angle in Defense Acquisition



Old

- ... Requirements in solicitations are being described in performance terms
- ... Military standards are cancelled

Source: "Specifications & Standards – New Way of Doing Business", June 29, 1994

Current

"DoD policy is to promote standardization of materiel, facilities, and engineering practices ..."

Source: DoD Defense Standardization Program website
<http://www.dsp.dla.mil>

Renewed interest in using life cycle process standards



The Life Cycle Process Angle in Defense Acquisition - 2

- Research at The Aerospace Corporation demonstrated that the use of a robust software development standard is needed to ensure mission success [Eslinger 2006]
 - The Aerospace experience showed that even the use of so-called mature process frameworks, such as the CMMI is inadequate, and **the government must make a robust software standard contractually compliant**
 - This conclusion is the result of extensive analysis of the 1994 acquisition reform*-induced failures on numerous space programs
 - The recommended use of software standards is outlined in two Aerospace Technical Operating Reports (TORs); see [Adams 2004] and [Adams 2005]
 - Note that the primary standard used in The Aerospace Corporation is a space-specific tailoring of MIL-STD-498 [DOD 1994] and J-STD-016-1995 [IEEE 1995]; which are actually the predecessors of ISO/IEC 12207 (to be discussed later)

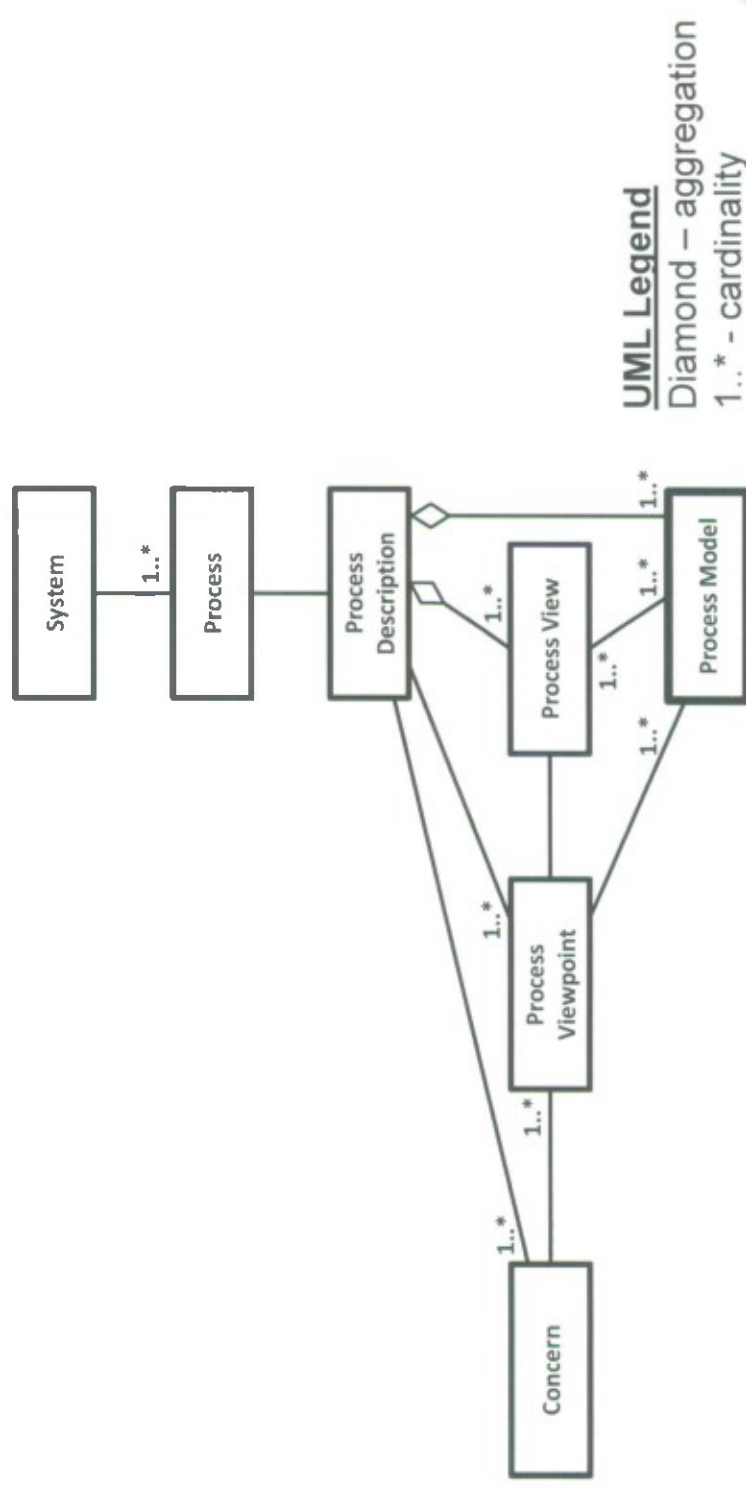
* [Perry 1994]



Process Life Cycle Modeling

Process Modeling

- A Unified Modeling Language (UML®) description of a simplified process metamodel is as follows



- A **process viewpoint** may cover multiple concerns from stakeholders
- A **process view** always conforms to a particular viewpoint but may relate to many process models



Life Cycle

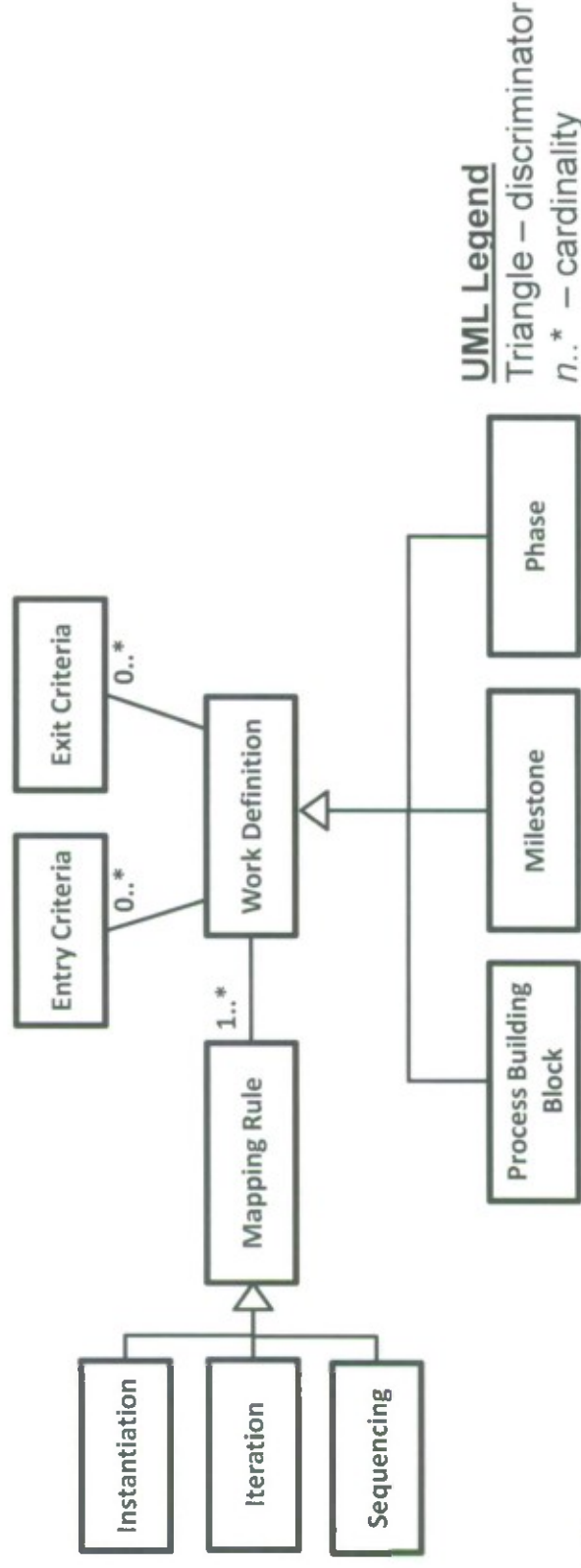
- The concept of life cycles has its origins in biology, and engineering adopted the term mainly for its metaphorical value
 - ***Life cycle in biology refers to a period involving different generations of a species***
 - The repetition (“cycling”) is only valid for species; in case of individual animals, plants, or organisms there is no cycle and sometimes even biologists refer to it as life history rather than life cycle
 - ***Life cycle in development refers to the evolution of a system, product, service, project, or other human-made entity from conception to retirement****
 - Similarly to biology, the life cycle phases of an actual system are always sequential and end with the phase-out of the system (“cradle to the grave”)
 - On the other hand, the development process from an enactment perspective is always repetitive (unless the system is unusually unique.)
 - *Note that these repetitions of the process do not represent iterations; such repetitions are supposed to yield identical systems*

* [ISO 2008b]



Life Cycle Viewpoint of a Process

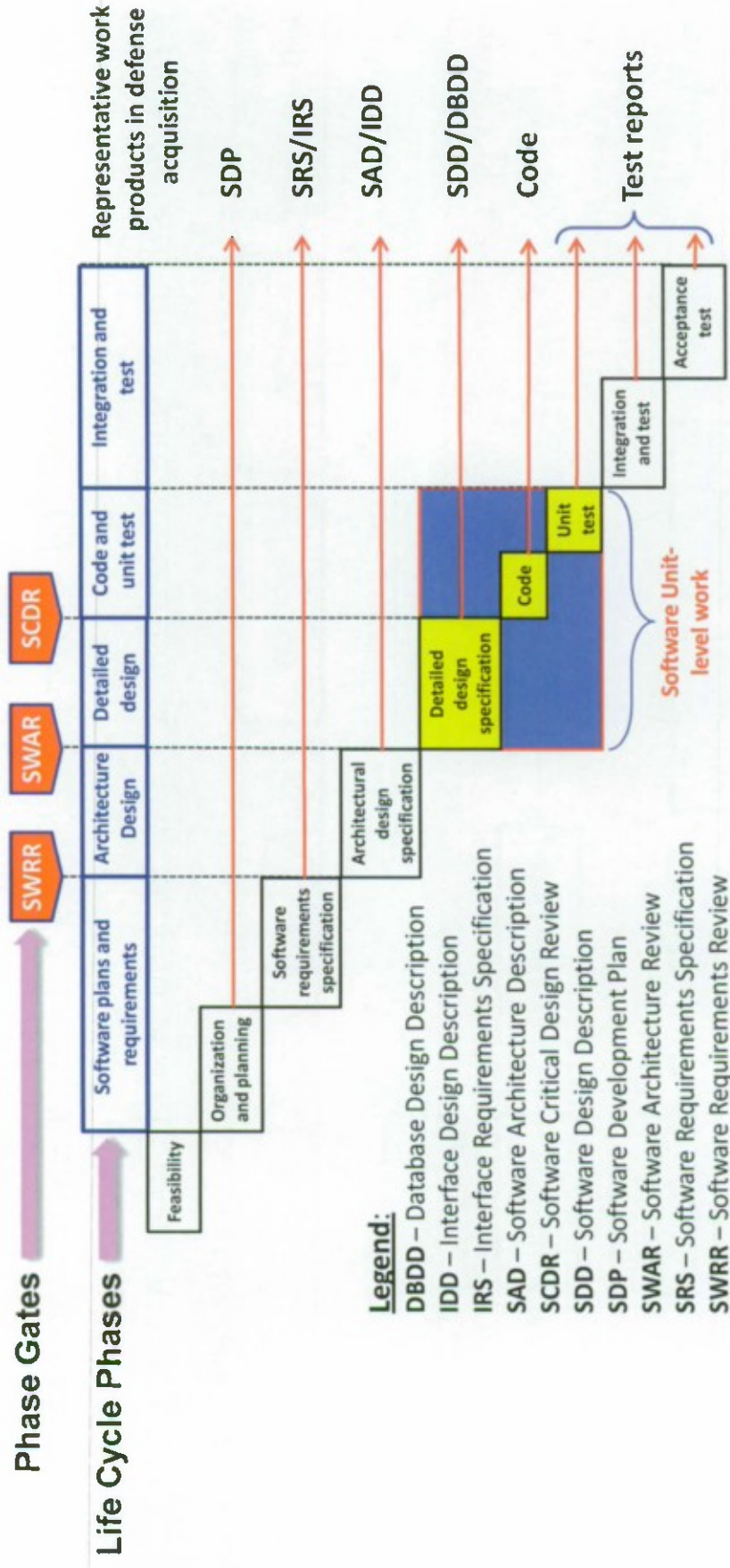
- Life cycle is a view associated with a process
 - *Life cycle viewpoint describes the modeling rules for such view*



- Instantiation
 - *The selected process building block is used only once when instantiated*
- Iteration
 - *Essentially it is localized, multiple instantiation; in one cycle at least some input is processed and some output created*
- Sequencing
 - *Ordering information that augments instantiation and iteration*



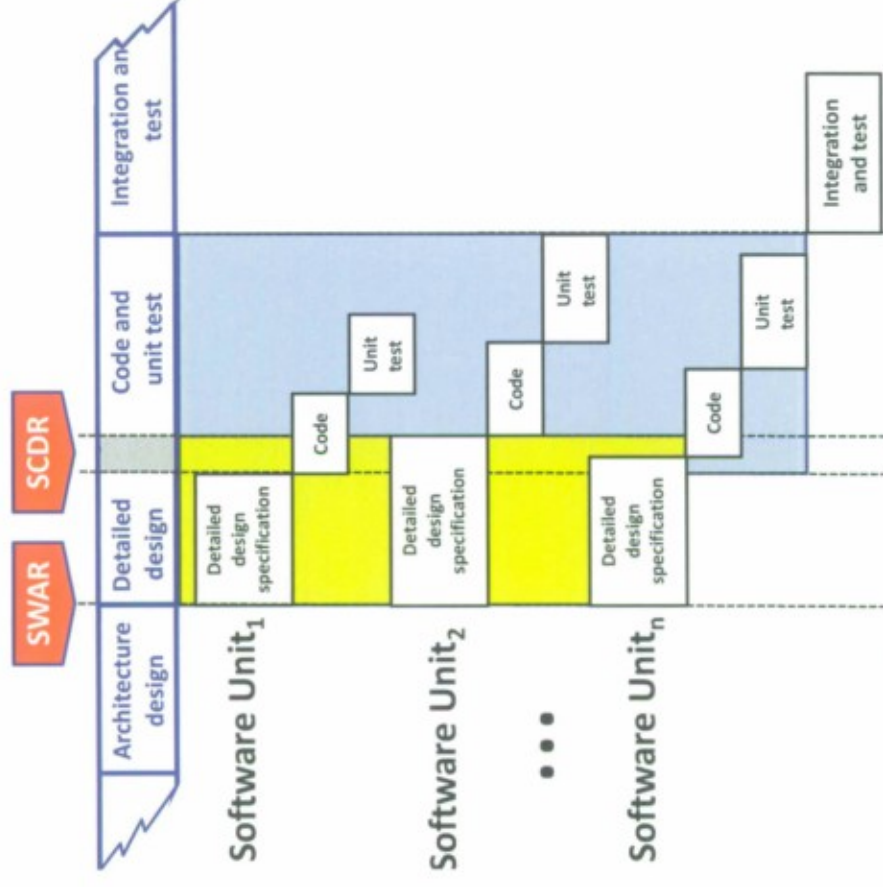
Life Cycle View of the Waterfall Process



- The Waterfall model is the “mother of all life cycle models”
 - Life cycle phases neatly map into activities
 - All activities are sequentially instantiated
 - Several phases end with an explicit phase-gate review
 - However, it contains numerous, simplifying abstractions (like all models, reflecting different objectives of the modelers)



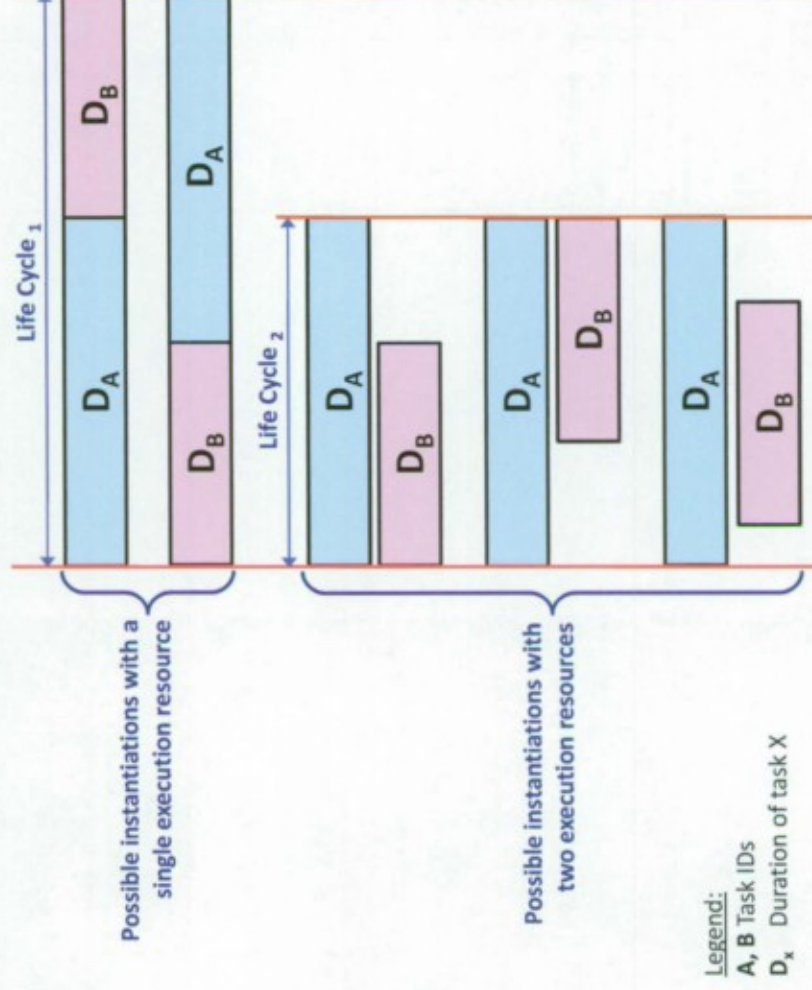
Simplifying Abstraction in the Waterfall: Unit-level Work



- Unit-level work represents independent and concurrent processes
 - *This is where the waterfall is a truly fitting metaphor; The falling streams of water don't meet before hitting the pool at the bottom*
- Note that the positioning and content of SCDR are ambiguous because phase boundaries are now blurred

Simplifying Abstraction in the Waterfall: Concurrency

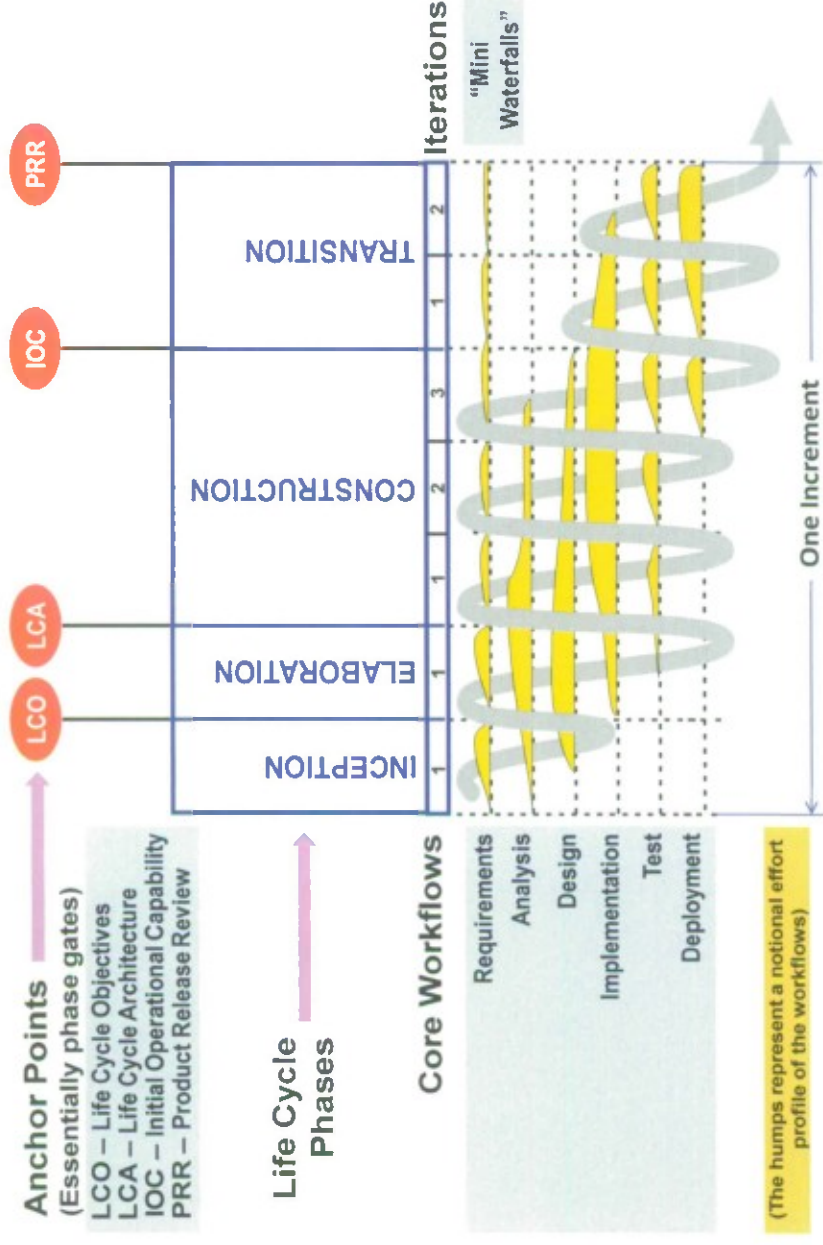
- The original depiction of the model does not show any concurrency for unit-level work
 - However, this is just a simplifying abstraction



- Having concurrent process threads depends on resource availability
 - In case of a single execution resource the process is always inherently sequential



Life Cycle View of IBM/RUP*, an Iterative/Incremental Development (IID) Process



- Selected characteristics of workflows in IBM/RUP
 - “Workflow” is IBM jargon for “process” – they are more than single activities
 - Workflows are sequentially instantiated but iterated in every phase
 - Workflows (the underlying activities) do not formally map into phases

* International Business Machines/Rational Unified Process



Why the Phase and Phase Gate Focus in Life Cycle Models?

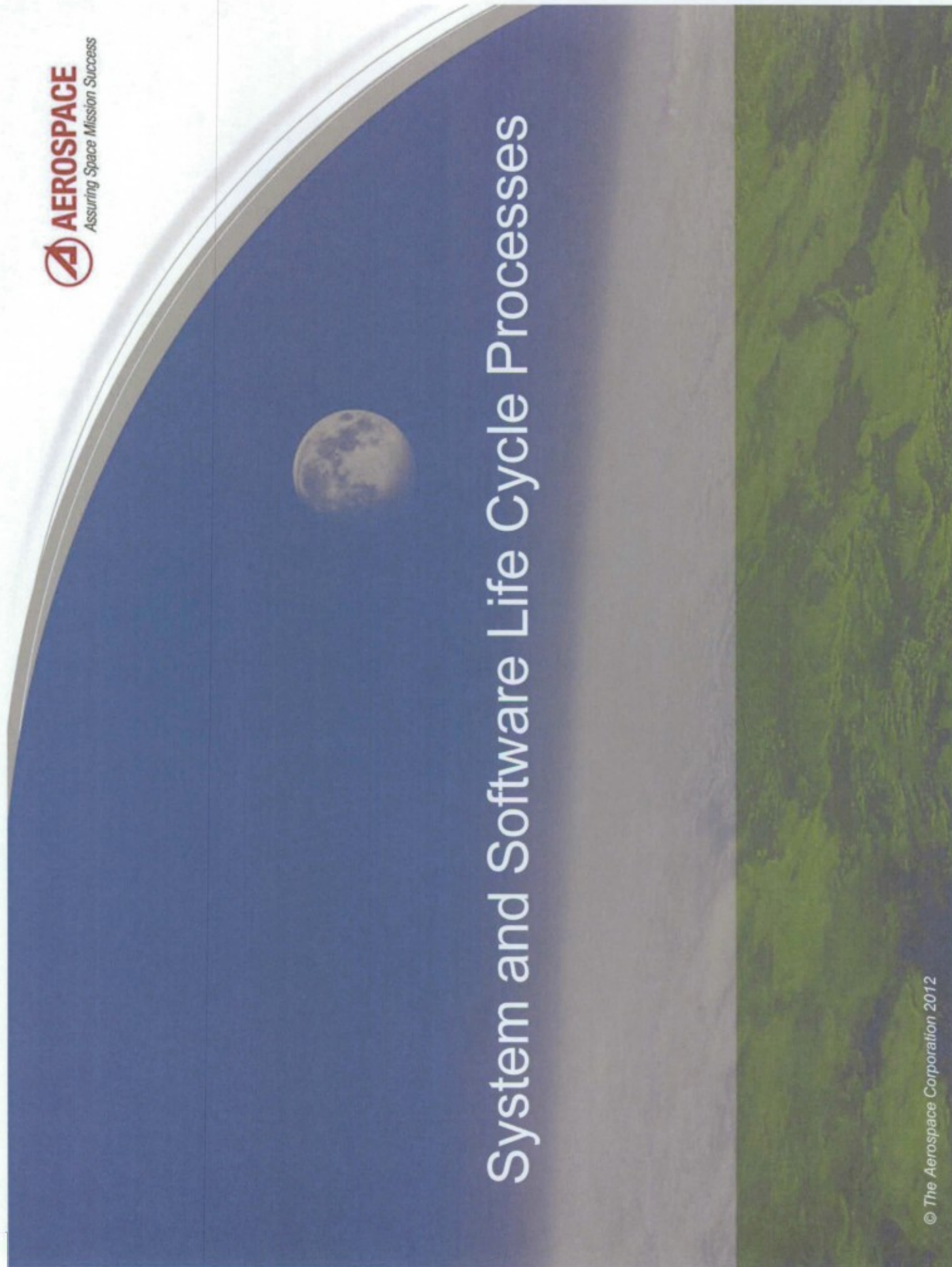
- The emphasis on phases and phase gates in the life cycle view of a process addresses primarily acquirer and customer concerns
 - *Historically this stakeholder focus evolved during the 70's and 80's due to difficulties with complex new product development endeavors*
 - *The idea took hold that the key to a robust development framework is crisp definition of development phases and the creation of a phase-gate process with solid transition criteria around the major milestones*
- The Waterfall process inherently incorporates these concepts
 - *It was published first for electro-mechanical product development*
 - *However, later it was also assumed that the model is applicable to software development as well and there is a 1:1 mapping of software development activities to life cycle phases*
 - *Progressive software methodologists fought this idea from the beginning and introduced various iterative and incremental approaches (e.g., IBM/RUP,) to counter the obvious deficiencies of the Waterfall model*
- Unfortunately, the early, rigid project management ideas have never been sufficiently reconciled with state-of-the-art software development; hence still the difficulties and ambiguity



Bad News and Good News in Life Cycle Modeling

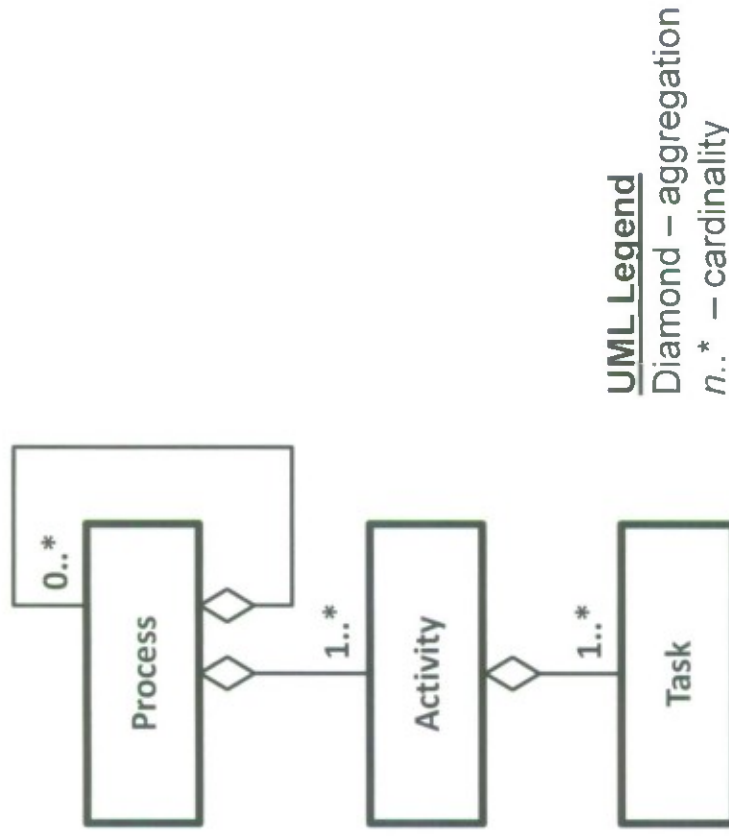
- Bad news
 - *There are no standards regarding the definition, modeling, and documentation of (process) life cycle models*
 - *None of the international standards bearing “life cycle” in their titles have these either*
- Good news
 - *The same... ☺*
 - The process architect of a particular development organization has total freedom to specify the organization’s preferred life cycle models





System and Software Life Cycle Processes

Structural Viewpoint of a Process*



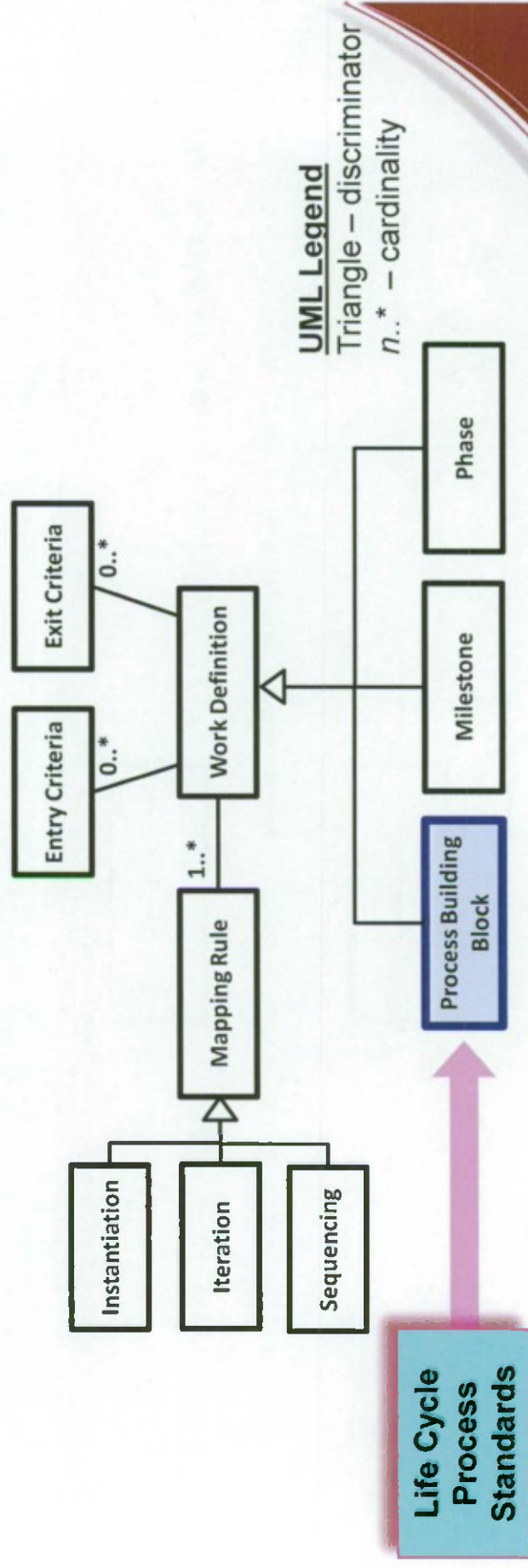
- Processes are aggregates of activities or contain at least one activity
- Similarly, activities are aggregates of tasks or contain at least one task
- However, a complex process itself can be an aggregate of processes
- Further elaboration of details depends on the process' stakeholders

* Adapted from [ISO 2008b]




What is a Life Cycle Process?

- Despite the fact that three, key international standards* bear the term “life cycle processes” in their titles, none of them provides a concise definition of what a life cycle process is
 - *In our definition, life cycle processes are processes that can be used as standard building blocks in defining a higher level process (e.g., system or software development process.)*



* [ISO 2008a], [ISO 2008b], and [IEEE 2006]

System Life Cycle Process Groups*

- Enterprise Process Group
 - Agreement Process Group
 - Organizational Project-Enabling Process Group
 - Project Process Group
 - Project Planning
 - Project Assessment and Control
 - Decision Management
 - Risk Management
 - Configuration Management
 - Information Management
 - Measurement
 - Technical Process Group
 - Stakeholder Requirements Definition
 - Requirements Analysis
 - Architectural Design
 - **Implementation**
 - Integration
 - Verification
 - Transition
 - Validation
 - Operation
 - Maintenance
 - Disposal
- 
- In case of software-intensive or software-only systems several system-level processes need to be interpreted/expanded for software
 - E.g., the Maintenance Process becomes Software Maintenance Process
 - The “Implementation” System Life Cycle Process is expanded via software-specific processes of ISO/IEC 12207 [ISO 2008b] (next slide)

* Based on ISO/IEC 15288 [ISO 2008a]



Software Life Cycle Process Groups*

- **Software Implementation Processes • Software Support Processes**
 - Software implementation
 - Software requirements analysis
 - Software architectural design
 - Software detailed design
 - Software construction
 - Software integration
 - Software qualification testing
- **Software Reuse Processes**
 - Domain engineering
 - Reuse asset management
 - Reuse program management
- Software documentation
- Software configuration management
- Software quality assurance
- Software verification
- Software validation
- Software reviews
- Software audits
- Software problem resolution

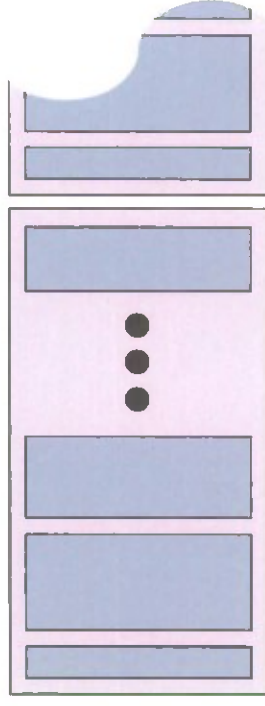
ISO/IEC 12207 life cycle processes are software-appropriate specializations or contributions to the outcomes of the system life cycle processes provided in ISO/IEC 15288

* Based on ISO/IEC 12207 [ISO 2008b]

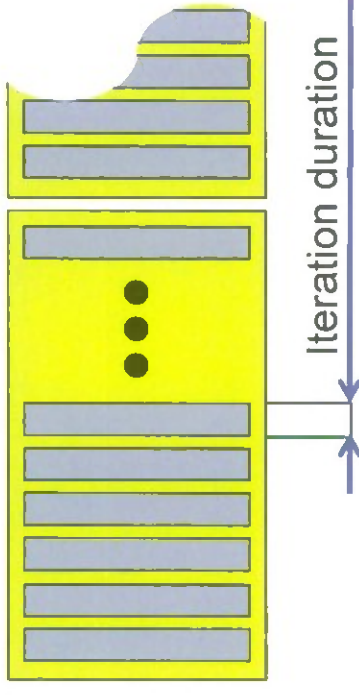


Life Cycle Processes Meant to be Used with Any Life Cycle Model

Iterative-Incremental Development (IID) Content (Requirements) Driven



Agile Timebox Calendar (“Clock”) Driven



- The example shows two different, iteration-based life cycle models
 - *The main, visible difference is the duration of the iterations, which of course has important estimation and planning implications*
 - *However, most of the life cycle processes that would be used to implement both processes could be essentially the same with slightly different tailoring*
- Unfortunately, the use of such universal and flexible standards has unintended, negative consequences (see next slide)



Life Cycle Process Challenges

- Mr. Weasel (and the standards* ...) say:



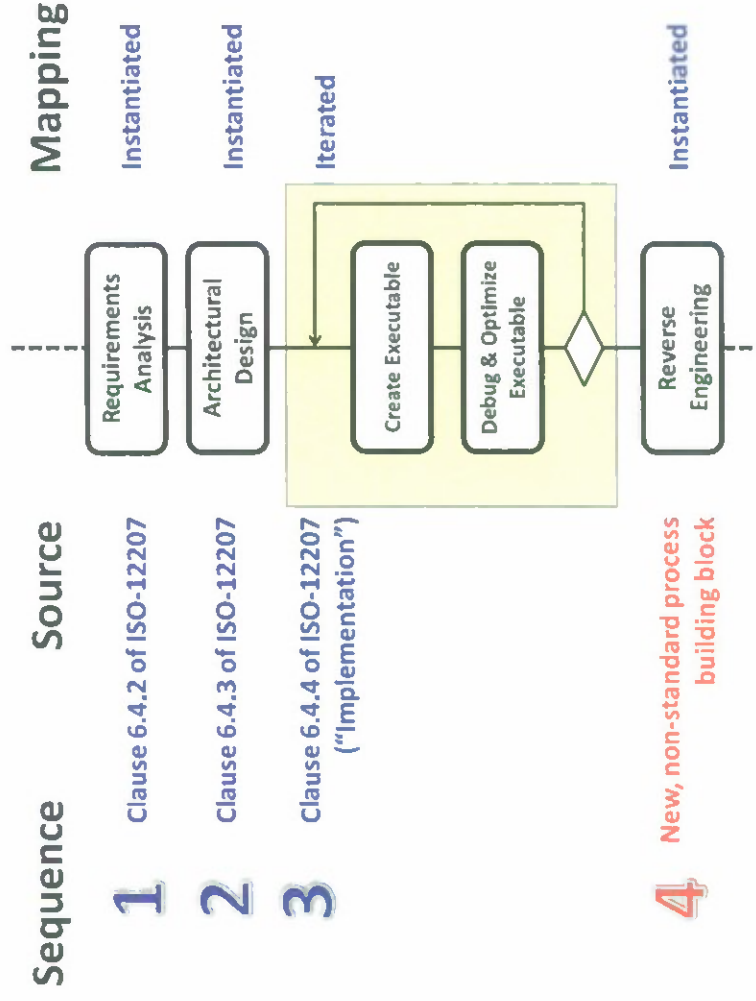
This is why the selection and documentation of a proper life cycle model are essential steps before attempting the use of life cycle process standards

* For recent guidance on implementing these concepts see [ISO 2011]



Life Cycle Process Challenges - 2

- Mr. George F. Will says*:
“Standards are always out of date. That’s why we call them standards.”
- However, new processes can be accommodated via tailoring
 - Example: *Introducing a reverse engineering step (i.e., the update of the original architectural design after code modifications) that is not part of the standard*



* On the “This Week with George Stephanopoulos” TV show, April 3, 2005

Conclusions

Conclusions

- **Process life cycle models** represent a particular view associated with a process
 - *Life cycle views, mainly for historical reasons, have an emphasis on phases and phase-gates*
 - *Unfortunately, there are no standards for life cycle models*
 - Consequently, life cycle modeling requires special attention and care from the process architect
- **Life cycle processes** are standard building blocks to be used in the definition of higher-level (e.g., system or software development) processes
 - *There are several, harmonized, international standards that can be used as sources of such standard process building blocks*
- However, the selection and documentation of a proper life cycle model are essential steps before the use of any life cycle process standards



Acronyms

CMMI	Capability Maturity Model Integration
DBDD	Database Design Description
DOD	Department of Defense
EIA	Electronics Industry Association
IBM/RUP	International Business Machines/Rational Unified Process
IDD	Interface Design Description
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IOC	Initial Operational Capability
IRS	Interface Requirements Specification
ISO	International Standards Organization
J-STD	Joint Standard
LCA	Life Cycle Architecture
LCO	Life Cycle Objectives
MIL-STD	Military Standard
PRR	Product Release Review
SAD	Software Architecture Description
SCDR	Software Critical Design Review
SDD	Software Design Description
SDP	Software Development Plan
SRS	Software Requirements Specification
SWAR	Software Architecture Review
SWRR	Software Requirements Review
TOR	Technical Operating Report
UML	Unified Modeling Language



References

Adams 2004	R. J. Adams, et al, Recommended Software Standards for Space Systems, TOR-2004(3909)-3406, May 5, 2004
Adams 2005	R. J. Adams, et al, Software Development Standard for Space Systems, TOR-2004(3909)-3537, Revision B, March 11, 2005
DOD 1994	MIL-STD-498 – Military Standard – Software Development and Documentation, 5 December 1994
IEEE 1995	J-STD-016-1995 - IEEE Standard for Information Technology -Software Life Cycle Processes - Software Development - Acquirer-Supplier Agreement
Eslinger 2006	S. Eslinger, Mission Assurance-Driven Processes for Software-Intensive Ground Systems, ATR-2006(8056)-1, September 30, 2006
IEEE 2006	IEEE Std 1074™-2006, IEEE Standard for Developing a Software Project Life Cycle Process, 28 July 2006
ISO 2008a	ISO/IEC 15288, Systems and software engineering – system life cycle processes, 1 February 2008
ISO 2008b	ISO/IEC 12207, Systems and software engineering – software life cycle processes, 1 February 2008
ISO 2011	ISO/IEC TR 24748-2:2011, Systems and Software Engineering - Life Cycle Management - Part 2: Guide to the Application of ISO/IEC 15288 (System Life Cycle Processes)
Perry 1994	DOD Memorandum for Secretaries of the Military Departments from the Secretary of Defense, "Specifications and Standards - A New Way of Doing Business." 29 June 1994 (Also called the "Perry Memo")
SEI 2010	Software Engineering Institute, CMMI for Development, Version 1.3, Technical Report CMU/SEI-TR-033, November 2010



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